Declaration
Navigability of the Upper Salt River

Submitted To: Salt River Project
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1 Introduction and Summary of Opinions

At the request of the Salt River Project Agricultural Improvement and Power District and Salt River Valley Water Users' Association (collectively, SRP), I have made an independent assessment of the navigability[1] of the Upper Salt River[2] to aid in determining ownership of the bed and banks of the river under the equal-footing doctrine. This assessment included review of the expert report and testimony of Dr. Stanley Schumm regarding this matter (Schumm, 2005), and independent review of additional relevant information, including various technical documents that will be cited below, the Arizona Division One Court of Appeals opinion that vacated and remanded for further proceedings the Arizona Navigable Streams Adjudication Commission (ANSAC) 2005 decision on navigability of the Lower Salt River and the U.S. Supreme Court's ruling in the PPL Montana case. My review also included a low-elevation overflight of the Upper Salt River from Granite Reef Dam to approximately White Rocks Rapid that is located about 13.5 miles downstream from the U.S. Highway 60 Bridge to gain first-hand knowledge of the present-day condition of the river and the surrounding landscape.

1.1 Qualifications

I am a registered Professional Engineer in ten states, including Arizona, with over 30 years of experience in analyzing the behavior of natural and manmade stream channels. I have a Ph.D. in Hydraulic Engineering from Colorado State University with emphasis on river mechanics, and I am currently a Program Manager and Discipline Lead for Hydraulic Engineering in the Surface Water Group of Tetra Tech, Inc. In 1989, I founded Mussetter Engineering, Inc. (MEI), and in 1994, Dr. Schumm joined me as part owner of MEI. From 1986 until his death in 2011, I collaborated with Dr. Schumm on a wide variety of projects related to stream channel processes. I was President and Principal Engineer of MEI during the time Dr. Schumm prepared his report and provided testimony to the ANSAC regarding this matter, and I was generally familiar with the work he performed in preparing the report and testimony. This familiarity was gained, in part, through discussions with Dr. Schumm about the information that he had obtained and the opinions that he was forming from that information. Over the course of my career, I have also performed significant technical work in Arizona related to stream channel processes through which I have gained first-hand knowledge of the climatic, hydrologic and geomorphic conditions in the Upper Salt River.

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[1] Arizona Revised Statutes (A.R.S.) section 37-1101(5) (2003) defines navigability as follows:

> "Navigable" or "navigable watercourse" means a watercourse that was in existence on February 14, 1912, and at that time was used or was susceptible to being used, in its ordinary and natural condition, as a highway for commerce, over which trade and travel were or could have been conducted in the customary modes of trade and travel on water.

In vacating and remanding for further proceedings, ANSAC's 2005 decision that the Lower Salt River was not navigable at the date of Arizona's Statehood (Case No CA-CV 07-0704), the Arizona Division I Court of Appeals concluded that *… ANSAC was required to determine what the River would have looked like on February 14, 1912, in its ordinary (i.e., usual, absent major flooding or drought) and natural (i.e., without man-made dams, canals, or other diversions) condition.*

[2] The Upper Salt River extends approximately 153 miles from Granite Reef Dam at the downstream end to the confluence of the Black and White Rivers at the upstream end (**Figure 1**).

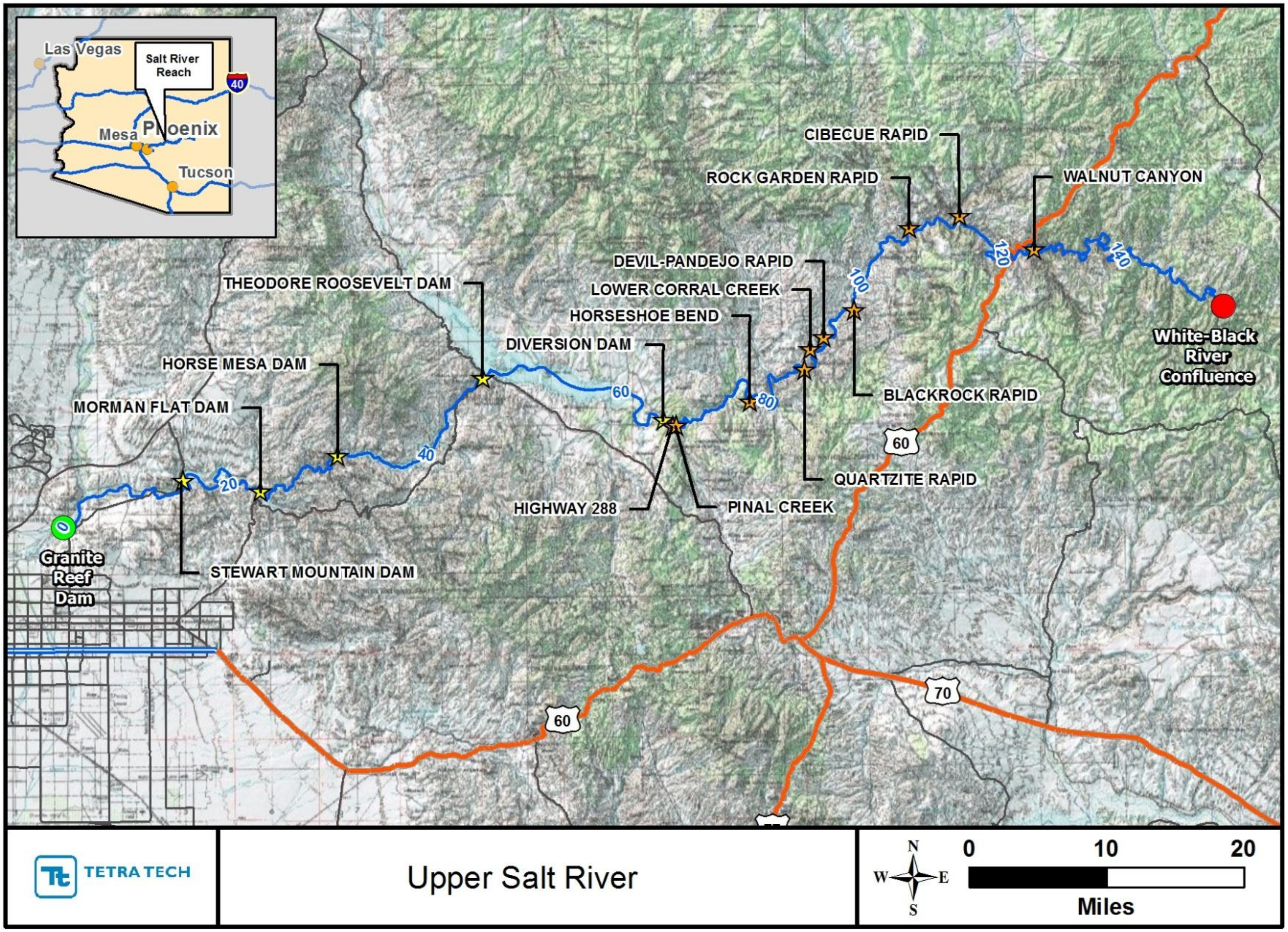

Figure 1. Vicinity map showing the limits of the Upper Salt River and key features.

1.2 Opinions

Based on my review of Dr. Schumm's report and background material, independent review of other background material, my knowledge of the climatic, hydrologic and geomorphic conditions along the Upper Salt River, and my knowledge of processes in arid stream channels, I agree with the opinions that were expressed by Dr. Schumm in his report and testimony, and offer the following clarifications and additional opinions for ANSAC's consideration in this matter:

1. With the exception of the approximately 3-mile portion of the reach about 100 river miles upstream from Granite Reef Dam know as Gleason Flat, the upstream approximately 93 miles of the Upper Salt River flow through a narrow, bedrock canyon. This portion of reach is steep (~22 ft/mi in the 53 mile reach between the head of Roosevelt Reservoir and Highway 60 and about 26 ft/mi between Highway 60 and the Black and White River confluence, with an approximately 6-mile reach between Highway 60 and Walnut Canyon having an even steeper slope of about 54 ft/mi), which alone would make navigation challenging, under the best of circumstances. Of more importance, however, this reach contains numerous rapids that would have made navigation impossible, or at the very least extremely dangerous, with the watercraft that were in customary use at and prior to the date of Arizona's Statehood in February 1912.
2. The characteristics of the approximately 13-mile portion of the Upper Salt River between Granite Reef Dam and Stewart Mountain Dam is less confined than the upstream, bedrock-controlled reach, which allows for a wide, braided[3] character. The historic braiding corridor occupied essentially the entire valley bottom. This portion of the reach has a single thread channel under current conditions due to the regulating effects of the upstream reservoirs.
3. Similar to the Gila River, a series of large floods occurred during the period between the late-1880s and 1912 that likely scoured away much of this vegetation, caused extensive bank erosion and channel widening, and maintained a wide, braided, multi-channel planform, a condition that would have made navigation impossible, or at the very least impractical, during significant portions of the year when flows in the river were low.
4. Granite Reef and Roosevelt Dams were completed in 1908 and 1911, respectively. These structures would have been a man-made impediment to navigation at the date of Arizona's statehood.
5. The majority of the approximately 53-mile reach that is mostly inundated by Roosevelt, Apache, Canyon and Saguaro Lakes is canyon-bound, similar to the upstream reach. This reach would most likely have had similar geomorphic characteristics to the upstream canyon-bound reach, including rapids and shallow riffles that would have made navigation impractical with the watercraft that were in customary use at and prior to the date of Arizona's statehood.
6. It is my opinion that segmentation of the Upper Salt River is not necessary because no significant segment of the river was navigable in its ordinary and natural condition.

[3]Planform refers the horizontal alignment of the channel (e.g., a meandering stream has a sinuous planform alignment.)

2 Basis for Opinions

2.1 General Character of Canyon-Bound and Dryland Rivers

River channels take on a variety of configurations that range from relatively narrow, single-thread cross sectional shapes with meandering planform to wide, braided cross sections with a relatively straight, down-valley alignment (Schumm, 1981; **Figure 2**)[4]. In general, the configuration results from the interplay between stream power and the resistance of the boundary materials to erosion (Graf, 2002). When the boundary materials are composed of modern-day alluvium, the configuration is also affected by the magnitude of the upstream sediment supply in relation to the local sediment transport capacity. Meandering configurations are most common in rivers with low stream power and high bank resistance resulting from erosion-resistant (i.e., cohesive) bank material and thick riparian vegetation. Braided configurations are common in rivers with high stream power, low boundary resistance and a high sediment load, particularly when a significant percentage of the load is carried as bed load[5].

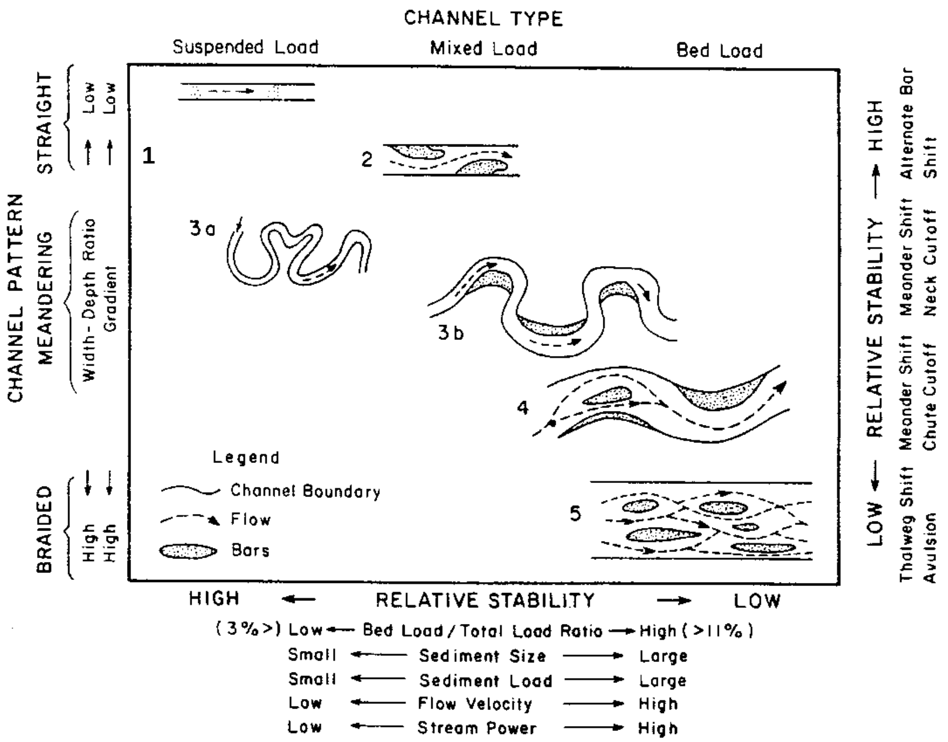

Figure 2. Channel classification based on pattern and type of sediment load, showing types of channels, their relative stability, and some associated variables (after Schumm, 1981).

[4]Meandering streams have a sinuous horizontal alignment consisting of a sequence of channel bends that are separated by relatively short, straight channel segments (often referred to as crossings). Meandering streams typically have only a single channel. Braided streams are streams that consist of an interlacing network of branching and reuniting shallow channels separated from each other by islands or channel bars.

[5]Bed load is that part of the total sediment load that moves by rolling, sliding or saltating along the streambed, in contrast to the suspended load that is carried in the water column above the channel bed.

The Upper Salt River flows through a narrow, bedrock-confined canyon over much of its length. Canyon-bound rivers of this type are strongly controlled by the characteristics of the bedrock that provide both lateral and vertical control on the form of the river, and by coarse-grained sediment and debris that is delivered to the river by floods and debris flows from the side canyons and by colluvial processes (i.e., gravity) from the canyon walls (O'Connor et al., 2003; Howard and Dolan, 1981; Graf, 1979). These rivers are typically supply-limited, which means that they can transport considerably more sediment than is being supplied from upstream. As a result, the sediment load has little influence on the overall form of the river, at least during flows up to moderate-magnitude floods. As is the case at many locations along the Upper Salt River, the bedrock can cause sharp breaks in the longitudinal profile that create waterfalls and rapids that can make navigation very challenging and dangerous, and in some cases, impossible. Coarse-grained sediment and debris delivered from the tributaries and side canyons often creates alluvial fans and bars that constrict the river, forming rapids that also severely limit navigability (Hereford et al., 1997; Graf, 1979).

With respect to the segments of the Upper Salt River that are not bedrock-confined, Graf (1983) argued that alluvial dryland river channels are not equilibrium forms. The morphology of the channel at any point in time is inherited from the last significant, flood-driven alteration, and this controls the channel form during the subsequent recovery period (Graf, 2002). Following the channel-altering flood event, the river channel returns to its pre-disturbance condition (i.e., it recovers) relatively slowly compared to the rate of adjustment during the flood through sedimentation in low energy areas and re-establishment of riparian vegetation on the surfaces that were disturbed by the flood. As a result, it is not possible to define a dominant discharge, because the larger, more infrequent flows are more geomorphically effective than the frequently occurring flows (Graf, 2002; Baker, 1977). During floods, the flows are so powerful that they can rapidly and significantly alter the channel and adjacent overbanks. The amount of alteration depends on many factors, including the magnitude and duration of the flows, the inflowing sediment load, the characteristics of the bed and bank material and riparian vegetation, and the degree to which the channel has recovered from the last major event. During the recovery periods of low- to moderate sustained flows, the channel form tends toward a single-thread, sinuous configuration within the overall wider cross section created by the disturbance flows.

The channel behavior described in the previous paragraph has been documented in a wide variety of settings. As noted in Dr. Schumm's expert report, for example, the Cimmaron River in southwestern Kansas was transformed from a narrow sinuous, 50-foot wide channel to a 1,200-foot wide, braided channel by a series of floods during the 1930s (Schumm and Lichty, 1963). Another notable example includes the Rio Salado, a tributary of the Rio Grande near San Acacia, New Mexico, where the channel width ranged from 12 feet to 49 feet in 1882, but widened to 330 to 550 feet by 1918 (Bryan, 1927). The Smoky Hill River originally *…had alternating sandy stretches and grassy stretches with series of pools* (sic)*. Later the former were widened and the latter were sanded up…..* (Smith, 1940). The Republican River was greatly affected by the flood of 1935: *Formerly a narrow stream with a practically perennial flow of clear water and with well-wooded banks, the Republican now has a broad, shallow sandy channel with intermittent flow. The trees were practically all washed out and destroyed, much valuable farmland…was sanded over, and the channel has been filled up by several feet.* (Smith, 1940)

An additional example is the Red River floodplain near Burkburnett, Texas, that was the object of intensive study to resolve a boundary dispute between Oklahoma and Texas (Glenn, 1925; Sellards, 1923). The Red River was never a narrow, meandering stream in historic times; a survey in 1874 showed the river to be about 4,000 feet wide. The channel, however, has undergone some important changes. For example, comparison of a map prepared in 1920 (Sellards, 1923) with aerial photographs taken in 1953 showed enlargement of the floodplain; 5.5 mi^2 of floodplain were added over a 10-mile reach of the river. In 1937, the river averaged three-quarters of a mile wide, close to the average for the 1874 survey. In 1953, the average width had decreased to half a mile. In 1957, the river averaged two-thirds of one mile wide, indicating significant widening between 1953 and 1957, during which period three large floods occurred in the reach.

The recorded history of the Gila River and many of its larger tributaries, including the Salt and Verde Rivers, documents cyclical changes that are very consistent with those described above. In a detailed study of the impacts of phreatophytes on the Gila River in the Safford Valley, Burkham (1972 and 1981) concluded that the historical character of the Gila River channel can be grouped into three time periods: 1846-1904, 1905-1917 and 1918-1970. From 1846-1904, the channel was relatively narrow, and it meandered through a floodplain covered with willow, cottonwood, and mesquite (**Figure 3**). Only moderate changes occurred in the channel width and sinuosity during this period. The maximum width was about 150 feet in 1875 and about 300 feet in 1903. In response to a series of large floods in the early-1900s that completely destroyed the meander pattern and floodplain vegetation, the average width of the river had increased to about 2,000 feet by 1917. The river then narrowed and developed a more sinuous planform with a densely vegetated floodplain between 1918 and 1970; by 1964, the maximum width had decreased to only about 200 feet.

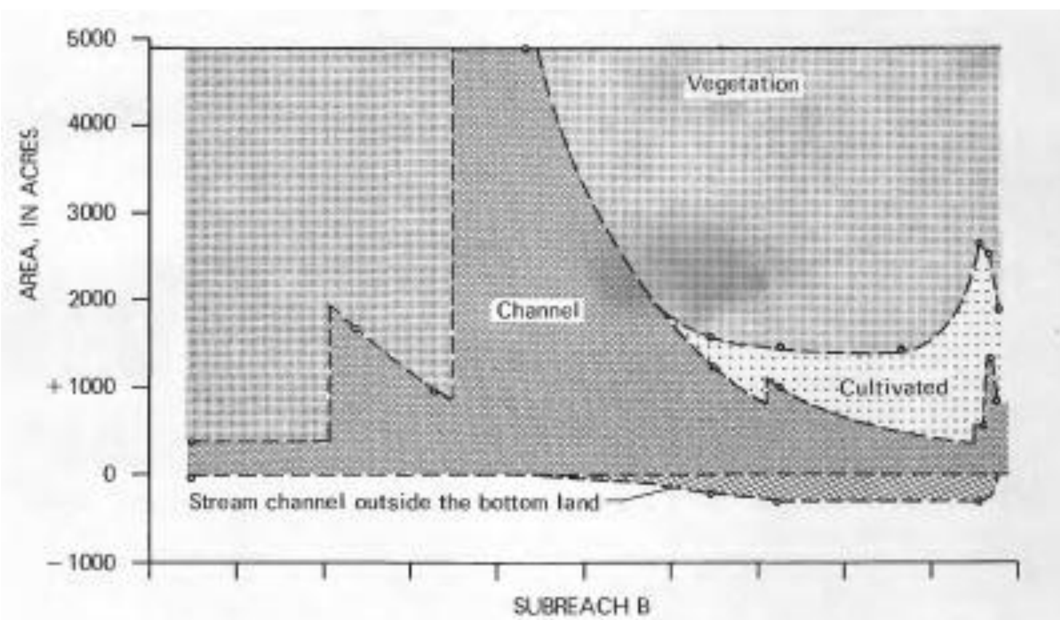

Figure 3. Historical changes in channel area of upper Gila River (San Simon to Pima) (from Burkham, 1972).

Huckleberry (1993) showed similar changes in the middle Gila River (**Figure 4**). In the late-1800s, the channel width averaged about 60 m (~200 feet), increasing to about 300 m (~1,000 feet) by about 1925 as a result of the large floods in the early-1900s, and then decreased back to about 40 m (~130 feet) by the 1940s. In response to large floods that occurred in the 1980s, the width increased to about 70 m (~230 feet) by the early-1990s.

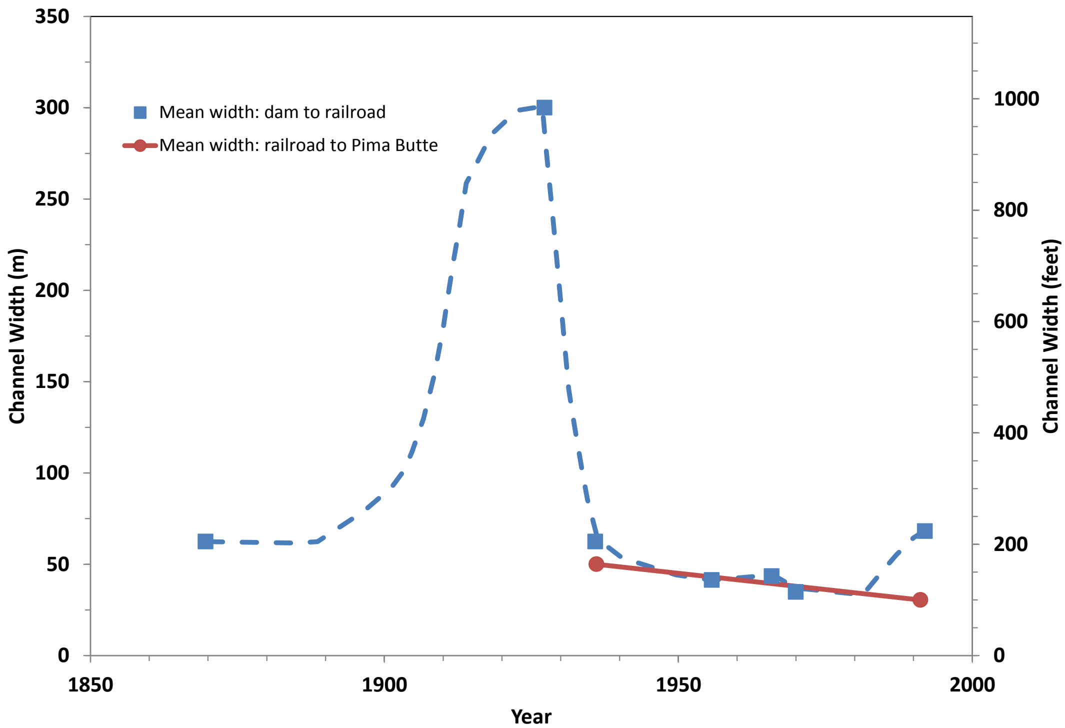

Figure 4. Changes in channel width for the Middle Gila River (modified from Huckleberry, 1993).

In summary, alluvial, rivers in the arid southwestern U.S. experience cycles of low (or non-existent) to moderate flows punctuated by large, infrequent, monsoon-driven flood events. During the low to moderate flow periods, they tend toward a single-thread, meandering planform, and during the infrequent, large floods, they can rapidly transform into a wide, braided, multi-channel planform in which the flow depths are highly irregular, both spatially and temporally. Both conditions are *natural and ordinary* conditions of the river. Particularly during the floods and the subsequent recovery periods following the floods, the multiple, individual channels in the braided planform tend to be very shallow and unstable. Where the rivers are confined by bedrock canyons, the planform and profile of the river is controlled by the bedrock and local deposits of coarse-grained material from debris flows emanating from the side canyons and from material falling directly into the river from the canyon walls. These features create rapids, shallow riffles, and in some cases, waterfalls that can make navigation extremely challenging or impossible, even for modern-day whitewater boats.

2.2 Historical (and Modern-day) Character of the Upper Salt River

Based on the topography, geology and locations of the existing dams and reservoirs, the existing Upper Salt River can be loosely divided into three reaches:

1. The approximately 93-mile canyon-bound upstream reach between the White and Black River confluence and the head of Roosevelt Reservoir,

2. The approximately 14-mile, alluvial, braided reach between Stewart Mountain Dam, that forms Saguaro Lake, and Granite Reef Dam.
3. The approximately 53-mile reach between the above two reaches that is mostly inundated by the Roosevelt, Apache, Canyon and Saguaro Lakes, and

As described in the following sections, the physical characteristics of each of these reaches would have rendered them non-navigable in their ordinary and natural condition at and prior to the date of Arizona's Statehood.

2.2.1 Canyon-bound Upstream Reach

The geologic conditions along the approximately 93-mile canyon-bound upstream reach of the Upper Salt River strongly indicates that the geomorphology has changed very little since the date of Arizona's statehood. This reach flows through a narrow, bedrock canyon that controls the planform alignment, longitudinal profile and width of the active river channel. In this setting, significant changes in geomorphology due to the direct action of the river occur over very long (geologic) time-frames that are orders of magnitude longer than the approximate century since Arizona's statehood. Because of the remoteness of the area, human activities that directly affect the geomorphic character of the river, including both direct physical modifications and changes in the flow regime, have been very limited. As a result, both the physical configuration of the river and the flows that occur under current conditions in this part of the reach are very similar o conditions at the time of statehood.

The overall gradient of the river in the canyon-bound reach is relatively steep (~22 ft/mi in the 53 mile reach between the head of Roosevelt Reservoir and Highway 60, and about 26 ft/mi between Highway 60 and the confluence of the Black and White Rivers) (**Figure 5**). The approximately 6-mile reach between Highway 60 and the mouth of Walnut Canyon is about twice as steep as the remainder of the reach, at about 54 ft/mi. For comparison, the average gradient of the approximately 64-mile reach between the mouth of the Verde River and Pinal Creek that is mostly inundated by the series of existing reservoirs is about 14 ft/mi.

Within the canyon-bound reach, bedrock is exposed in both the bed and banks of the river in many locations, providing direct vertical and lateral control that creates steep drops in the river bed elevation that form rapids (**Figures 6 and 7**). In many other locations, large caliber sediment and debris from the adjacent side canyons constrict the river (**Figures 8 and 9**). The large, mostly immobile debris controls the vertical profile, creating steep drops in bed elevation and rapids. In still other locations, constrictions in the valley width and bends in the valley alignment create upstream backwater[6] conditions at high flows when coarse-grained sediment is being transported, causing the transported sediment to deposit and form large cobble bars. During subsequent lower flows, the river is constricted to a relatively narrow channel along the sides (or in some cases, across the middle) of the bars, forming rapids or shallow riffles (**Figures 10 and 11**). In many instances, large boulders that have fallen from the bedrock valley walls in the above-described areas create additional roughness and hazards to navigation. In all cases, the rapids and riffles represent significant impediments to navigation by the watercrafts that were in use at and prior to the time of Arizona's statehood.

[6] Backwater is a term used in hydraulic engineering to describe the local increase in water-surface elevation and depth, and flattening of the water-surface slope, upstream from a flow constriction.

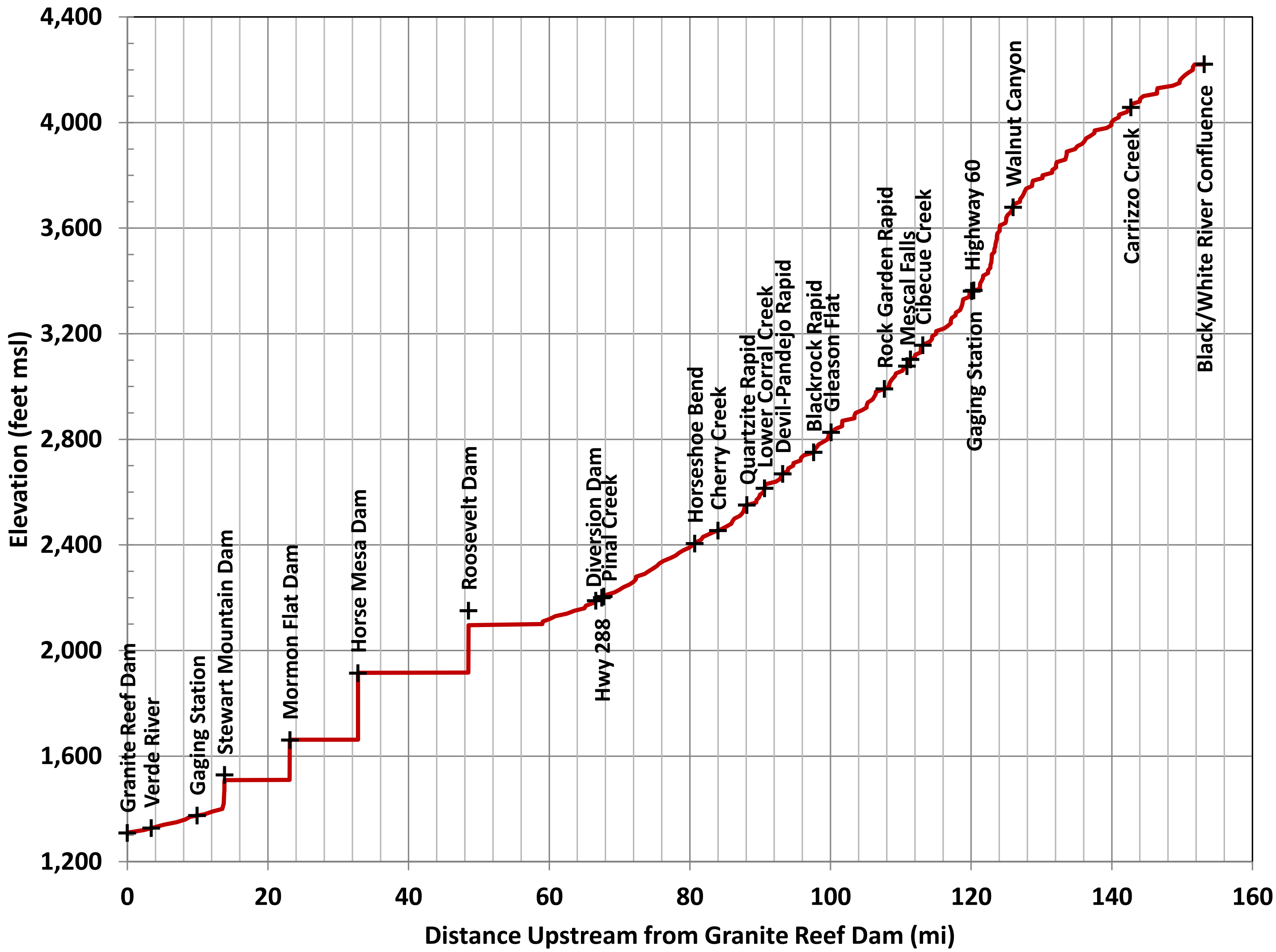

Figure 5. Longitudinal profile of the existing Upper Salt River. Only a sample of the rapids and features in the canyon-bound portion of the reach upstream from Roosevelt Reservoir are shown. (Elevation data from Natural Resources Conservation Service National Elevation Data 10-m resolution Digital Elevation model.)

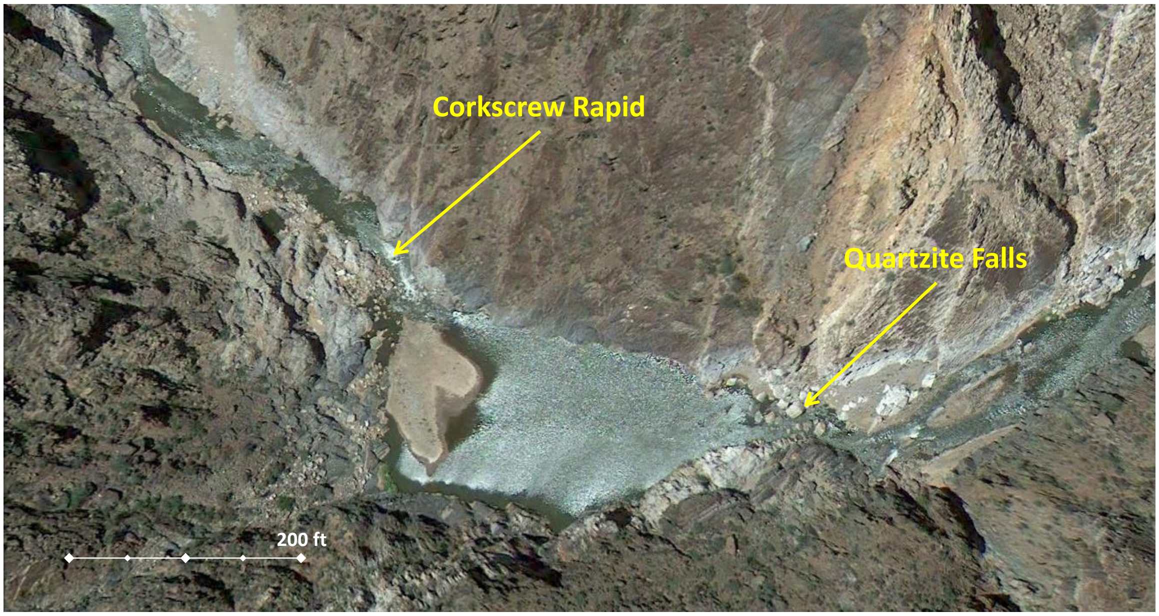

Figure 6. Aerial view of Corkscrew Rapid and Quartzite Falls (~RM 80[7]) illustrating a typical location where bedrock crops out directly in the bed of the river (Photo taken June 5, 2012; Discharge ~90 cfs).

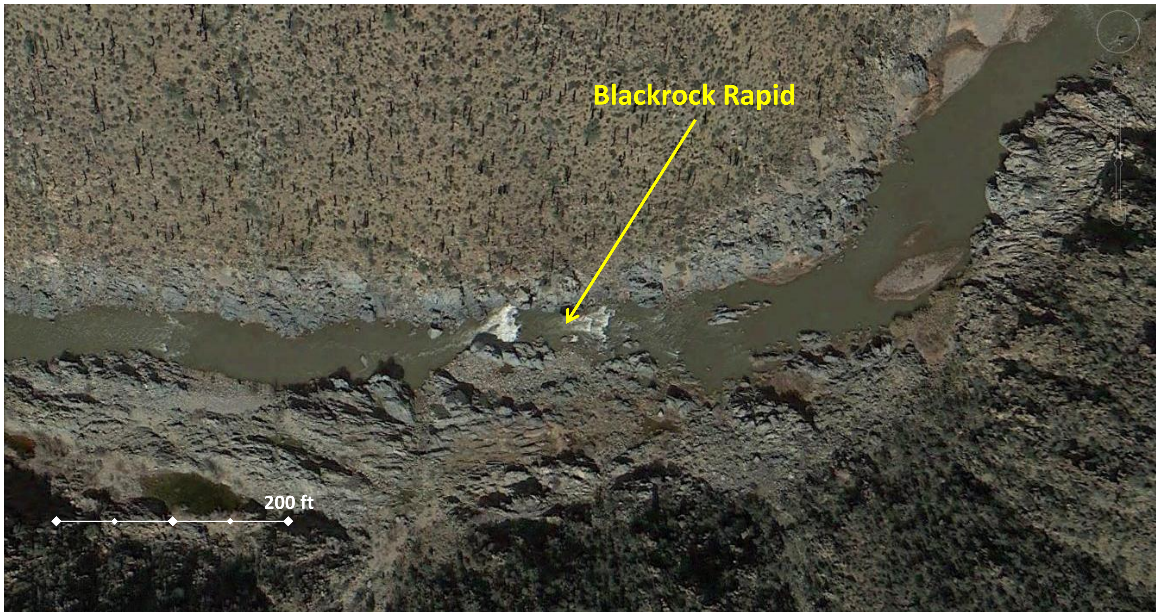

Figure 7. Aerial view of Blackrock Rapid (RM 97.6) illustrating a typical location where bedrock crops out directly in the bed of the river (Photo taken June 5, 2012; Discharge ~90 cfs).

[7] RM refers to distance in river miles upstream from Granite Reef Dam.

Figure 8. Aerial view of mouth of Lower Corral Creek and rapid (same name, ~RM 90.6) illustrating a typical location where sediment and debris from tributary constricts the river (Photo taken November 1, 2010; Discharge ~140 cfs).

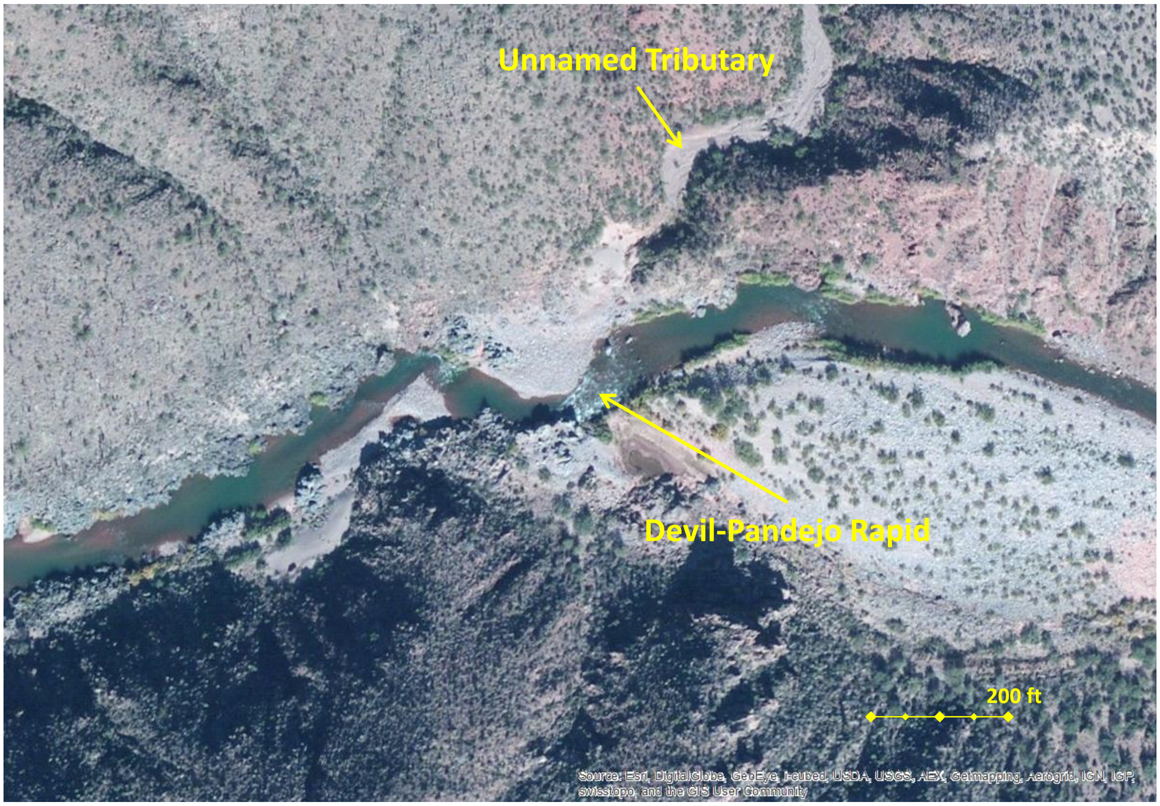

Figure 9. Aerial view of mouth of unnamed tributary and Devil-Pandejo Rapid (~RM 93.2) illustrating a typical location where sediment and debris from the unnamed tributary constricts the river. There may also be bedrock in the bed of the river at this location (Photo taken November 1, 2010; Discharge ~140 cfs).

Figure 10. Aerial view of apex of Horseshoe Bend Rapid (~RM 81) showing a typical backwater-formed gravel bar and shallow riffles/rapids (Photo taken November 1, 2010; Discharge ~140 cfs).

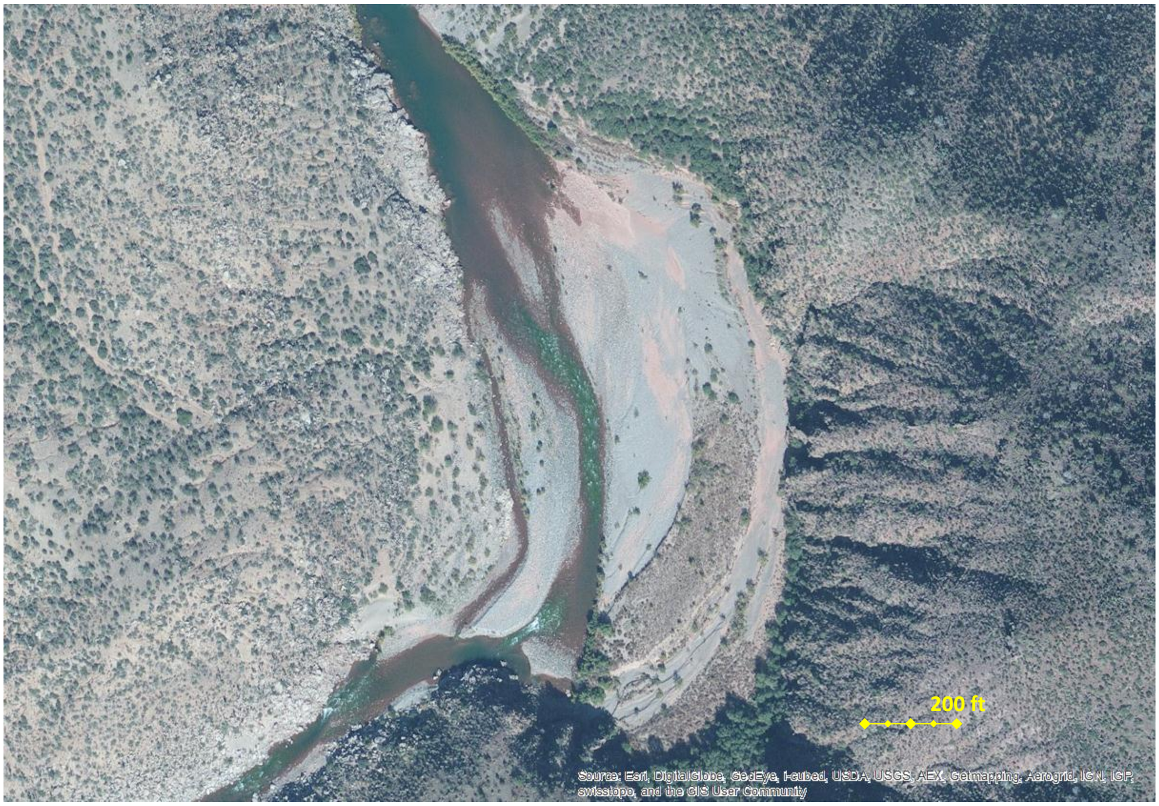

Figure 11. Aerial view of apex of portion of Upper Salt River near RM 105 showing a typical backwater-formed gravel bar and shallow riffles/rapids (Photo taken November 1, 2010; Discharge ~140 cfs).

In this regard, it is significant to note that the portion of this reach between Highway 60 and Highway 288, just upstream from Roosevelt Lake, is popular for whitewater rafting using modern kayaks and small inflatable rafts that are designed specifically for recreational use in such environments. These types of watercraft were not available at the date of Arizona's statehood. USDA Forest Service (USFS) information about this reach contains ample warning of the dangers:

> *There are several rapids which can go to a solid Class IV[8] at certain water levels. This river is usually run in small rafts and in kayaks. It is **not** suitable for… open canoes, etc. It is also unsuitable for large rafts.* (USFS, 1995, p1)
>
> *The Salt River Canyon is a very remote and potentially dangerous place. The river is a solid Class III-IV run, and is not recommended for novices and beginners.* (http://www.fs.usda.gov/detail/tonto/passes-permits/?cid=fsbdev3_018757)

The USFS (1995) guide contains descriptions of at least 23 named rapids in the approximately 36-mile reach downstream from Highway 60. One of these rapids (Quartzite Falls, Figure 4, **Figure 12**) is notoriously dangerous, even for skilled whitewater boaters. This rapid required a difficult portage to pass prior its being surreptitiously modified by blasting in 1998, an act for which eight men were convicted for damaging government property. The individuals responsible for the blasting allegedly did so to remove the impediment to navigation out of concern for public safety, as a number of people had drowned attempting to navigate the rapid. Even after the blasting, this rapid remains one of the most challenging on the river.

The period of the year when there is sufficient water to permit even whitewater boating is very limited, generally extending only from March 1 through May 15 in normal years, and even shorter periods in dry years. In fact, the March 9, 2014, edition of the Arizona Daily Star reported that commercial rafting companies have cancelled their 2014 seasons on the Upper Salt and Verde Rivers due to the lack of water. This report contained the following quote from the owner of the Wilderness Aware Rafting Company:

> *We need an absolute minimum of 400 cfs to get the boats out without having to drag it over the rocks.*

Based on the data from the Salt River near Roosevelt and Salt River near Chrysotile gages (USGS Gage Nos. 9498500 and 9497500, respectively) that are located near the Highway 288 and Highway 60 Bridges, respectively, the discharge in this part of the reach is less than 400 cfs about 60 percent of the time, on average, over the entire year and about 20 percent of the time during the typical rafting season (**Figure 13**).

An approximately 3-mile section of the canyon-bound reach between RM 99 and RM 102 known as Gleason Flats is relatively unconfined, and thus, responds to large floods by developing a braided, multi-channel planform with highly variable flow depths, as conceptually described in Section 2.1. Even this portion of the canyon-bound reach contains a named rapid (Gleason Rapid, **Figure 14**) that would have limited navigability.

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[8] The American Whitewater Association defines as Class IV rapid as follows:

> *Intense, powerful but predictable rapids requiring precise boat handling in turbulent water. Depending on the character of the river, it may feature large, unavoidable waves and holes or constricted passages demanding fast maneuvers under pressure. A fast, reliable eddy turn may be needed to initiate maneuvers, scout rapids, or rest. Rapids may require "must make" moves above dangerous hazards. Scouting may be necessary the first time down. Risk of injury to swimmers is moderate to high, and water conditions may make self-rescue difficult. Group assistance for rescue is often essential but requires practiced skills.*

Figure 12. View looking upstream of Quartzite Rapid (lower, center) (Photo by B. Mussetter, October 29, 2013).

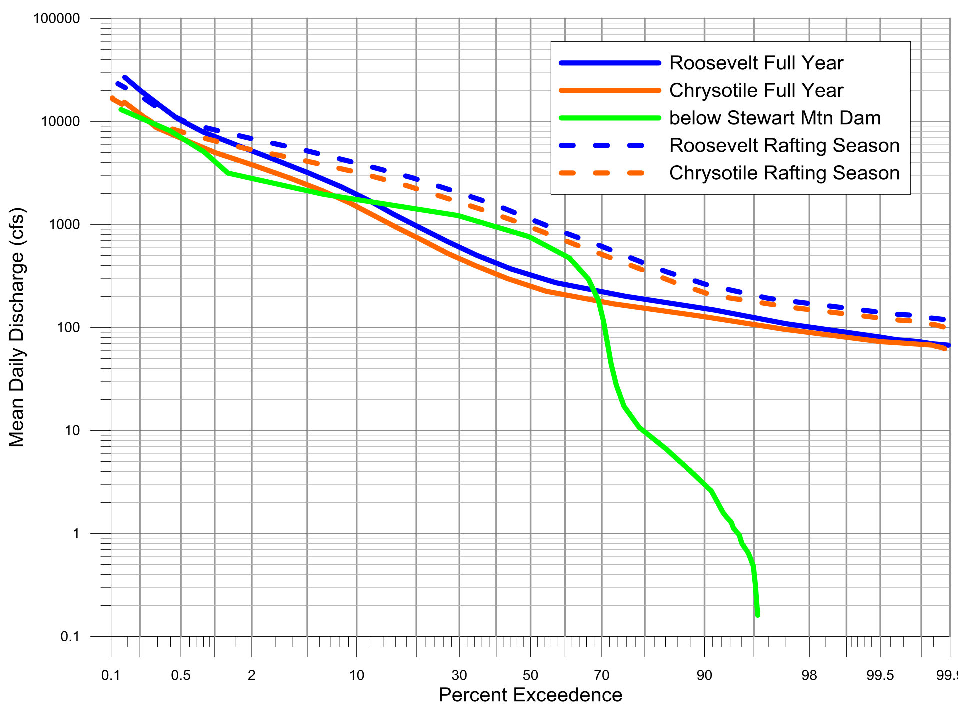

Figure 13. Mean daily flow duration curves for the *Salt River near Roosevelt* (USGS Gage No. 9498500) and *near Chrysotile* (USGS Gage No. 9497500) gages for complete water years and during the primary whitewater rafting season (March 1 – May 15).

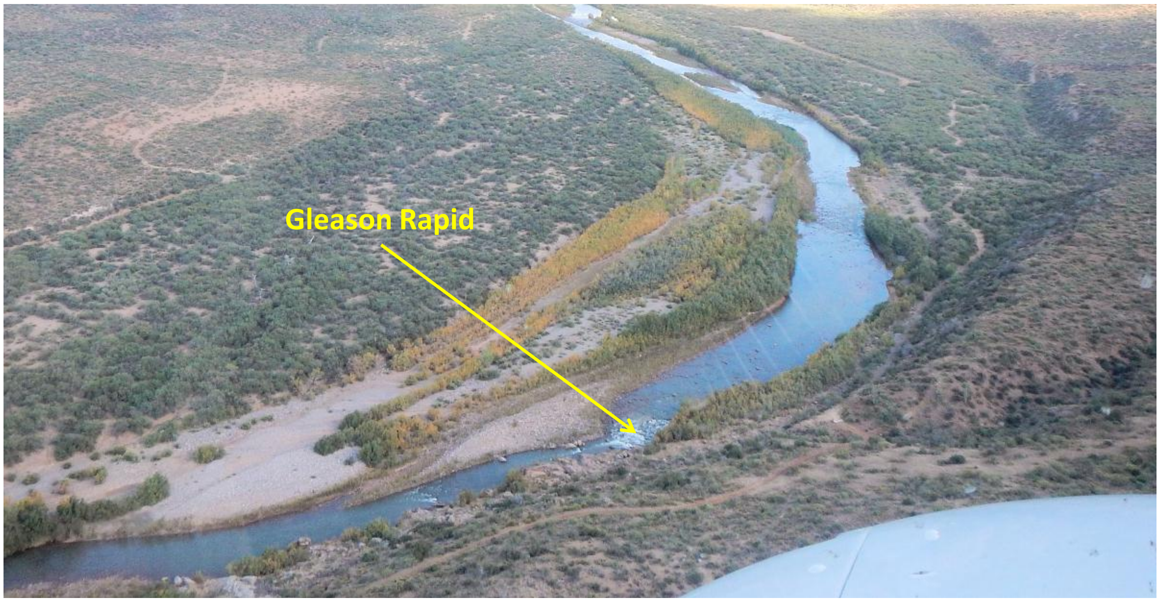

Figure 14. View looking upstream of the middle portion of Gleason Flats and Gleason Rapid (Photo by B. Mussetter, October 29, 2013).

2.2.2 Braided Downstream Reach

The portion of the Upper Salt River between Granite Reef and Stewart Mountain Dams is generally braided, with the braiding corridor occupying much or all of the valley bottom (**Figure 15**). A photo of the same area taken in 1934 shows the same braiding pattern, but with considerably less vegetation (**Figure 16**). The 29-foot high Granite Reef Dam is located at the downstream end of this reach (**Figure 17**). Completed in 1908, this dam would have been a barrier to navigation at the date of Arizona's statehood. The backwater effect of the dam extends about 2 miles upstream (**Figure 18**). Prior to construction of the dam, the backwater-affected portion of the reach would have had wide, braided characteristics that are similar to the remainder of the reach below Stewart Mountain Dam.

Both photos shown in Figures 15 and 16 were taken after completion of the four upstream dams; thus, the geomorphic and vegetation characteristics of the river reflect the significant effects of the upstream flow regulation. Based on the data from the USGS *near Roosevelt* gage that is located upstream from Roosevelt Lake and the *below Stewart Mountain Dam* gage that reflects the effects of the regulation, the upstream facilities significantly reduce the annual peak discharges that create the disturbance regime that removes vegetation and drives the braiding process, but have a less significant effect on the total amount of flow passing through the reach (**Figures 19 and 20**). For the common period of record from Water Year (WY) 1935 through WY2013, the annual peak discharge at the *near Roosevelt* gage exceeded 13,300 cfs in half the years (i.e., the median discharge) and exceeded 60,000 cfs in 13 of the 79 years (~16 percent, or about 1 in 6 years); whereas, the median annual peak discharge at the *below Stewart Mountain Dam* gage was only 2,340 and 60,000 cfs was exceeded only once (WY1980; peak discharge of 64,000 cfs). In comparison, the average annual runoff volume past the *near Roosevelt gage* during this period was about 581,000 ac-ft, and about 667,000 ac-ft at the *below Stewart Mountain Dam* gage[9]. Prior to construction of the dams, large peak flows would

[9]Note that the drainage area above the *near Roosevelt* gage is 4,306 mi^2, compared to 6,232 mi^2 at the *below Stewart Mountain* gage, an increase of about 45 percent between the two gages.

have occurred in the downstream portion of the reach on a regular basis, just as they do under existing conditions in the canyon-bound, upstream portion of the reach, but with typically larger peak discharge due to the larger drainage area.

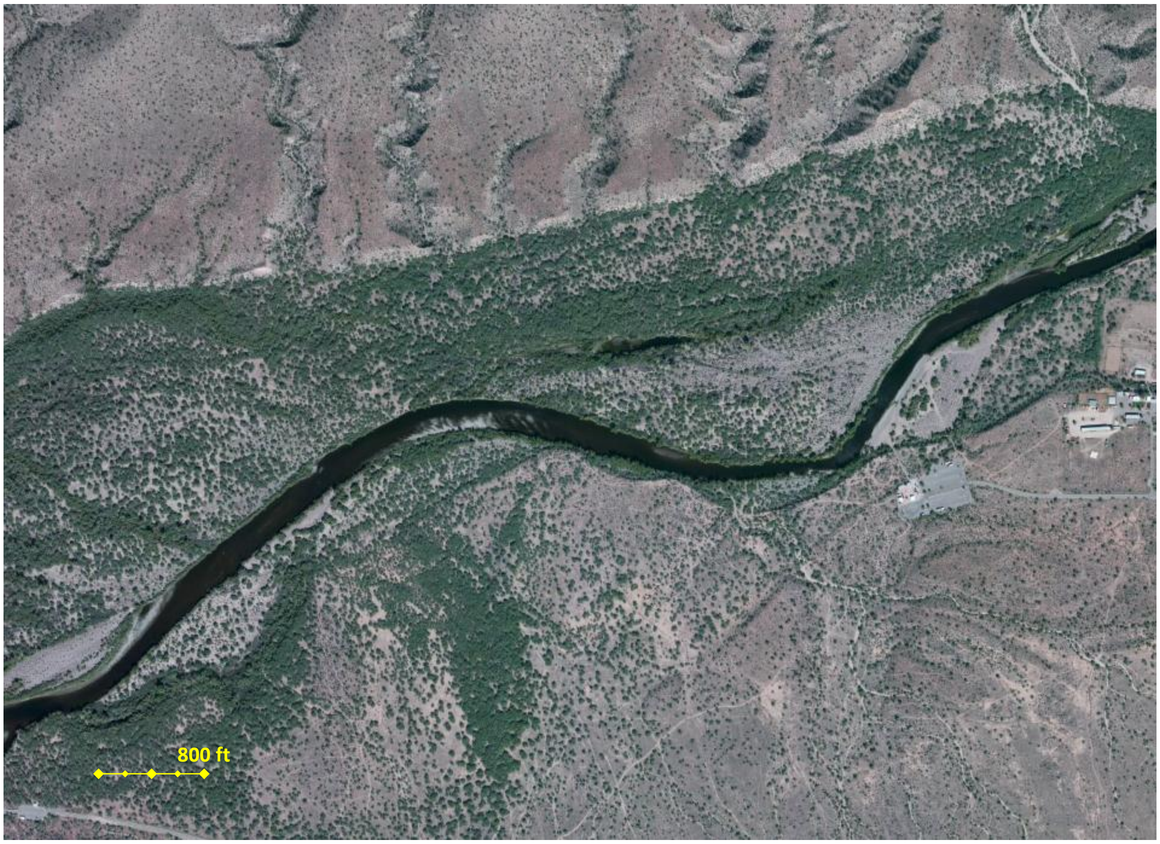

Figure 15. Aerial view of ~2-mile portion of Upper Salt River beginning ~1 mile upstream from Verde River showing typical historic braiding pattern (Photo date November 1, 2010).

Figure 16. Aerial View of ~2-mile portion of Upper Salt River beginning ~1 mile upstream from Verde River (Photo dated 1934).

Figure 17. View looking upstream toward Granite Reef Dam (approximate center of photo) (Photo by B. Mussetter, October 29, 2013).

Figure 18. View looking upstream of the backwater-affected reach upstream from Granite Reef Dam (Photo by B. Mussetter, October 29, 2013).

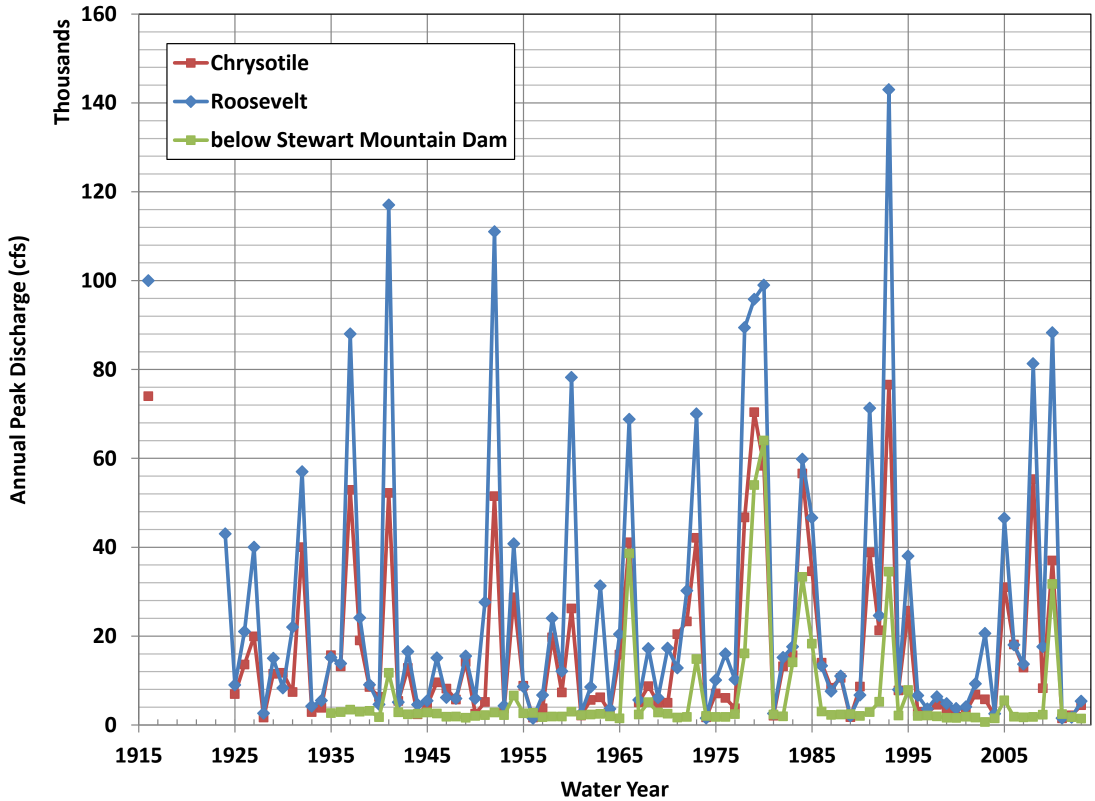

Figure 19. Annual peak discharge at the *Salt River near Chrysotile* (USGS Gage No. 9497500), *near Roosevelt* (USGS Gage No. 9498500), and *below Stewart Mountain Dam* (USGS Gage No. 9502000) gages.

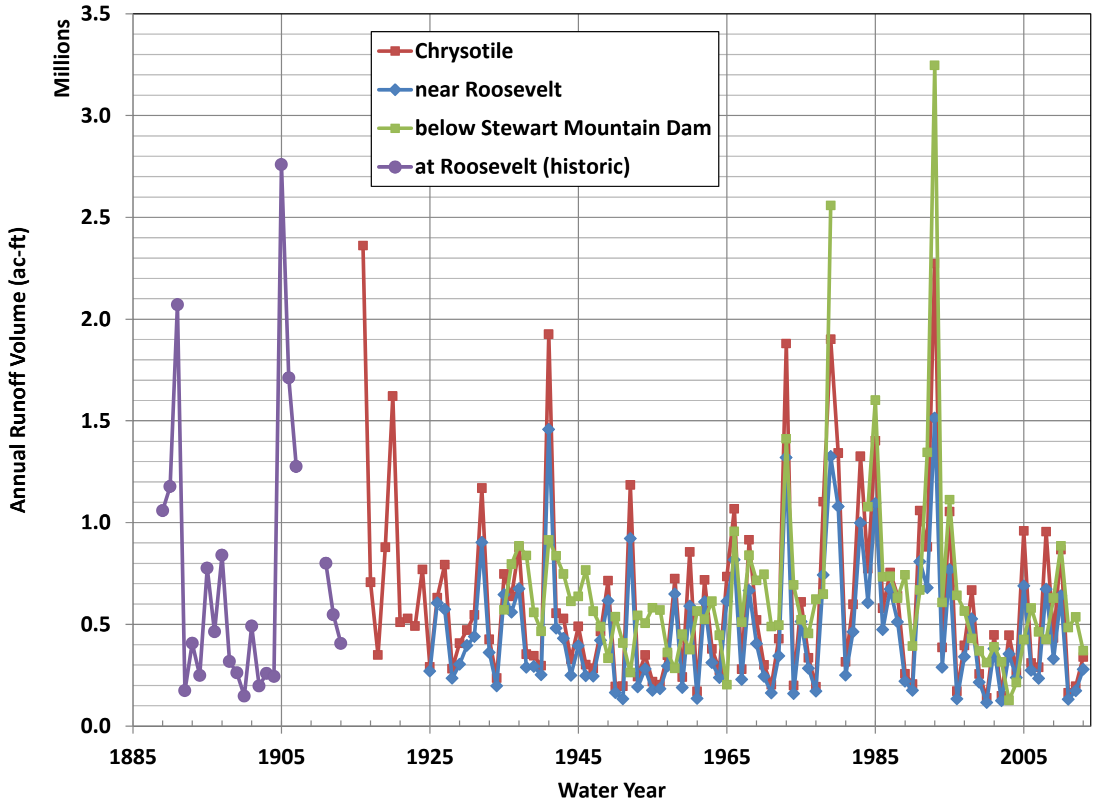

Figure 20. Annual runoff volume at the *Salt River near Chrysotile* (USGS Gage No. 9497500), *near Roosevelt* (USGS Gage No. 9498500), and *below Stewart Mountain Dam* (USGS Gage No. 9502000) gages. Also shown are the annual runoff volumes at the *Salt River at Roosevelt* gage for the period from 1880 through 1913 (data from USGS, 1954).

As is true for most dryland rivers, there is strong correlation between the annual flood peak and the annual runoff in the Upper Salt River (**Figure 21**). The annual runoff volumes at the historic *Salt River at Roosevelt* gage that was located at the approximate site of the existing Roosevelt Dam show runoff volumes exceeding 1 million ac-ft during 6 of the 22 years for which data are available between WY1889 and WY1913 (Figure 20); indicating that large floods occurred during these years. The largest annual flows (and presumably, largest annual peaks) occurred in WY1891 and WY1905-WY1907, when there were no significant upstream diversions and prior to completion of the water storage projects that include Roosevelt Dam. Based on this information, the portion of the Upper Salt River below present-day Stewart Mountain Dam was most likely strongly braided, with little in-channel vegetation at the date of Arizona's statehood as a result of these floods.

The hydrologic history of the Upper Salt River is very similar to that of the Gila and Verde Rivers, and all experienced large floods in the late-19th and early-20th Centuries. Meko and Graybill (1995) reconstructed the annual flows in the Gila River in the vicinity of Safford using tree ring data. His results show that the mid- to late-1800s corresponded to an extended period of low flows, but these were punctuated by periods of unusually high flows (**Figure 22**). The Meko and Graybill (1995) analysis clearly shows that, while some of the floods in the early-1900s were unusually large, the Gila River experienced large annual flow volumes, and thus,

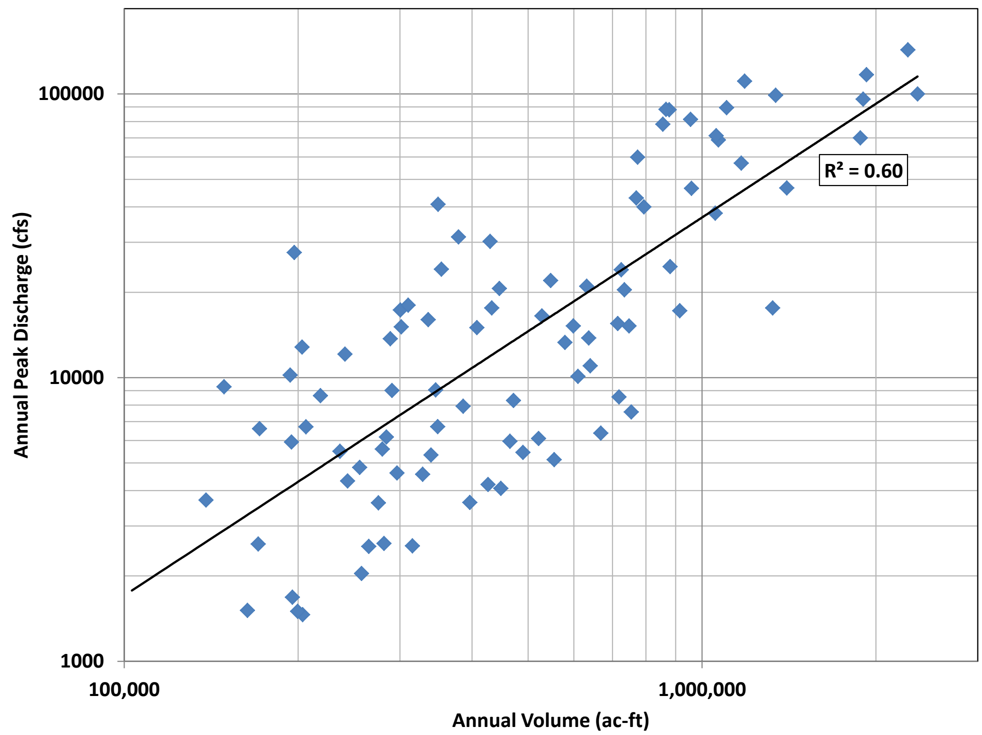

Figure 21. Comparison of annual peak discharge and annual runoff volume at the *Upper Salt River near Roosevelt* gage (USGS Gage No. 9498500).

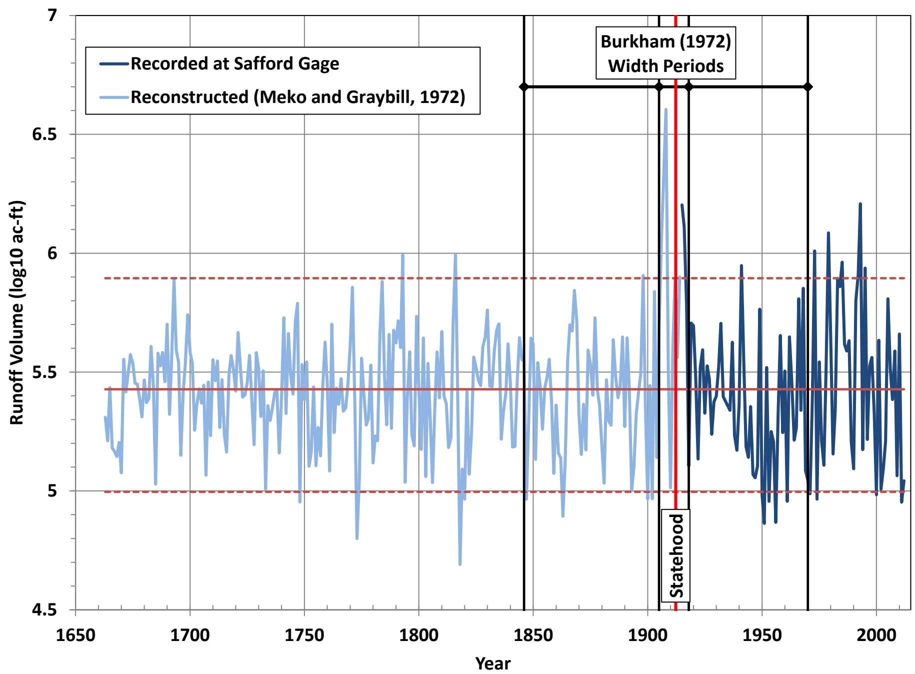

Figure 22. Time-series plot of Gila River annual discharge (1663-1914 from reconstruction of Meko et al., 1995; 1915-2012 from recorded flows at USGS Gage No. 09448500, Gila River at Head of Safford Valley. Also shown are the periods of different typical channel widths identified by Burkham, 1972). Solid horizontal line is median, dashed lines are 10th and 90th percentiles (i.e., 10 percent of the values fall above and below these lines, respectively).

large floods prior to the dry period in the mid- to late-1800s. These floods would have caused the river to become wide and braided, similar to the character during the early-1900s and the ensuing drier period.

Although the effects of significant upstream flow regulation that began with completion of Roosevelt Dam in 1911 on total flow volume are less than on the flood disturbance regime, it does significantly affect the duration and timing of the flows by reducing the duration of high and low discharges and increasing the duration of flows in the intermediate range (Figure 13). This has a compounding effect on the characteristics of the river that affect navigability because it severely limits the disturbance regime that occurred prior to the dams that created the wide, braided, and unvegetated channel, provides additional water to sustain the vegetation that grows on the braid bars and provides longer periods of intermediate magnitude flows for which depths might be suitable for navigation. The effects of flow regulation on increasing riparian vegetation and channel narrowing are well-documented in the literature (Shafroth et al., 2002; Grams and Schmidt, 2002; Hupp et al., 1994; Williams and Wolman, 1984). As a result of these effects, the alluvial reach of the Upper Salt River between Stewart Mountain and Granite Reef Dams in its current condition would be much more likely to sustain navigation, as defined under the Arizona Revised Statutes, than it would have at and prior to the date of Arizona's Statehood.

The Arizona Division 1 Court of Appeals found that *ordinary* conditions of the river means the absence of *major flooding or drought* and *natural* conditions means the absence of *man-made dams, canals and other diversions* (See Footnote 1). While it is reasonable to exclude the limited periods when the river is actually experiencing major flooding or drought when considering navigability, the effects of these periods on the long-term character of the river cannot be discounted. The wide, braided planform that is created by major flooding persists for a significant period and influences the form of the river throughout the ensuing low- to moderate flow periods. Extended droughts can also have a long-term impact on the character of the river, especially when followed by a major flood, because they tend to diminish the amount of riparian vegetation, making the river even more susceptible to widening and braiding during flooding.

2.2.3 Reservoir Reach

Construction of Roosevelt Dam was completed in 1911; thus, the dam, itself, would have been an impediment to navigation at the date of statehood. The specific characteristics of approximately 53-mile reach through the existing reservoirs at and prior to the date of Arizona's statehood are less certain than the upstream canyon-bound reach and the downstream braided reach because historical information is limited and inundation by the reservoir prevents direct assessment of the characteristics of the valley floor. In spite of those limitations, the available information strongly suggests that this reach would also have been non-navigable at and prior to the date of statehood. A significant part of the inundated reach between the dams is canyon-bound; thus, would have very likely had geomorphic characteristics similar to the upstream reach, including rapids created by bedrock outcrops, tributary debris fans and colluvium (**Figures 23 through 25**). According to Gregory (1979) (as reported by Greenwald and Gilpin, 1997), an alluvial floodplain was present in the area occupied by Roosevelt Lake and this was *the first place where water from the upper Salt River would have been available for canal irrigation.* This portion of the Upper Salt River that is now inundated by Roosevelt Reservoir may have been similar to the downstream, alluvial reach and the upstream Gleason Flats reach that had a wide, braided character that would have also made navigation impractical using the watercraft in use at and prior to the date of Arizona's statehood.

Figure 23. View looking downstream from approximately 2 miles below Roosevelt Dam showing the canyon-bound character of the reach (Photo by B. Mussetter, October 29, 2013). Note that the water shown in this photo is much deeper than it would have been under *ordinary and natural conditions* because of the backwater effects of Horse Mesa Dam.

Figure 24. View looking downstream from approximately 4 miles below Horse Mesa Dam showing the canyon-bound character of the reach (Photo by B. Mussetter, October 29, 2013). Note that the water shown in this photo is much deeper than it would have been under *ordinary and natural conditions* because of the backwater effects of Mormon Flat Dam.

Figure 25. View looking upstream of Mormon Flat Dam showing the canyon-bound character of the reach (Photo by B. Mussetter, October 29, 2013). Note that the water shown in this photo downstream from the dam is much deeper than it would have been under *ordinary and natural conditions* because of the backwater effects of Stewart Mountain Dam.

2.2.4 Conclusion

Based on the above information, it is my opinion that the Upper Salt River would not have been suitable for navigation on a consistent and reliable basis under *ordinary and natural conditions* at and prior to the date of Arizona's statehood. Specific aspects of this overall conclusion are described in more in Section 1.2 at the beginning of this declaration.

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